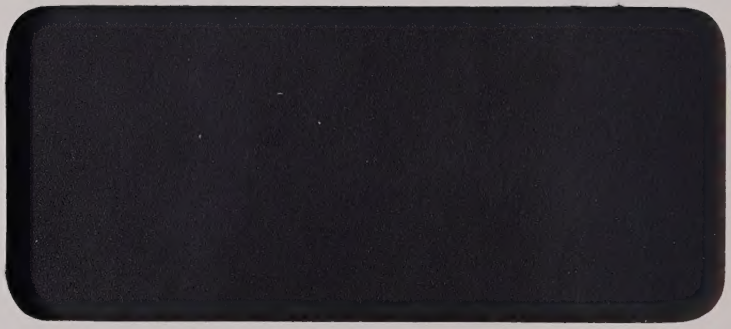
Modular Stabilised Power Supplies PM16-PM19

Instruction Manual

ADVANCE



Modular Stabilised Power Supplies PM16-PM19

Instruction Manual

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MANUAL PART No.23350 CPC 1/69/2000

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INTRODUCTION SECTION 1

The PM16-PM19 are a range of high performance, modular Stabilised Power Supplies. All units have a continuously variable voltage output from OV to 7V with an individual output current rating in the range 1 to 10A.

Units may be operated in constant voltage or constant current modes. Overload protection is provided by the constant current mode which automatically comes into operation at a preset level between 5% and 105% of maximum output current. Overvoltage protection at the output terminals is provided by a high speed circuit which can be preset between 1.5V and 8V.

A programming facility allows external resistors to be connected for remote control of the voltage and current modes and the overvoltage protection circuit. This is possible because of a Ω/V and Ω/A relationship incorporated in the design of the control circuits.

For all units, output stabilisation against variation in AC supply voltage is better than 10,000:1 (or 30μV change) and is effected by a closed loop automatic voltage control circuit.

A four terminal sensing network compensates for the resistance of the leads to the load. All units have an output impedance of less than 0.25Ω at 100kHz.

The use of silicon semiconductors ensures that the units can be operated safely in ambient temperatures up to +60 °C.

NO programming on separate internal terminal block.

Input Voltages

100, 105, 110, 115, 120, 125V AC
200, 210, 220, 230, 240, 250V AC
All ± 10% and at a frequency of 45-450 Hz.

Internal Programme - Voltage Mode

All units zero to 100% of maximum output voltage. Output continuously variable by means of front panel control.

External Programme - Voltage Mode

All units zero to 100% of maximum output voltage.
Scale Factor
100Ω/V ± 10%

Regulation

Line
Less than ±(0.001% + 30μV) for ± 10% AC line variation at any specified tap.
Load
Less than (0.02% + 1mV) for a no load to full load swing.

Ripple

Less than 400μV pk-pk (250μV, typical)

Temperature Coefficient

Internal Programming - Less than (0.02% + 200μV) change per °C
External Programming - Less than (0.013% + 100μV) change per °C plus coefficient of programming resistor.

Output Impedance

Less than 0.25Ω at 100 kHz.

Recovery Time

Less than 50μs.

Output Currents

PM16 0 to 1A; PM17 0 to 3A; PM18 0 to 5A; PM19 0 to 10A.

Internal Programme - Current Mode

All units 5% to 105% of maximum output current. Output continuously variable by means of front panel control.

External Programme - Current Mode

All units 5% to 105% of maximum output current.
Scale Factor ± 1%
PM16 1,000Ω/A; PM17 333Ω/A; PM18 200Ω/A; PM19 100Ω/A

Regulation

Line - Less than ±(0.02% + 200μA) change for ± 10% AC line variation at any current in the range 5% to 100% of full rated current.
Load - Less than (0.1% + 2mA) change in output current for the maximum change in load resistance within the rated working range.

Ripple

Less than 0.1% pk-pk of the set output current.

Temperature Coefficient

Less than 0.1% of maximum rated output current per °C.

PROTECTION

Overcurrent
Constant current overload protection variable from 5% to 105% of full load rating.

Overvoltage
Overvoltage protection by SCR across output terminals in conjunction with internal fuse. The trip voltage may be varied over the range 1.5V to 8V by means of internal control mounted on Overvoltage Board or may be programmed externally by 1k potentiometer.

Overvoltage Recovery Time 50μsec.

Operating Temperature Range (all units)
0°C to +60°C ambient.

M.T.B.F.
Greater than 30,000 hours for all units.

Insulation (all units)
Floating output must not exceed ±250V DC from earth. Insulation between supply input and earth, and between supply input and output, better than 10MΩ at 500V DC.

Dimensions and Weight (all units)

Type	Width		Height		Depth		Weight (approx)	
	in.	cm	in.	cm	in.	cm	lb. oz.	kg
PM16	3 9/32	8.33	5 1/8	13.02	5 1/8	13.02	4 - 6	2.0
PM17	3 9/32	8.33	5 1/8	13.02	9 1/4	23.5	7 - 8	3.4
PM18	4 41/64	11.80	5 1/8	13.02	9 1/4	23.5	10 - 12	
PM19	7 3/8	18.73	5 1/8	13.02	9 1/4	23.5	15 - 8	

3.1 Installation

Power supply modules PM16 to PM19 are secured in position by four fixing screws. The fixing screws centre data for all units is given in Table 1 and Fig. 1.

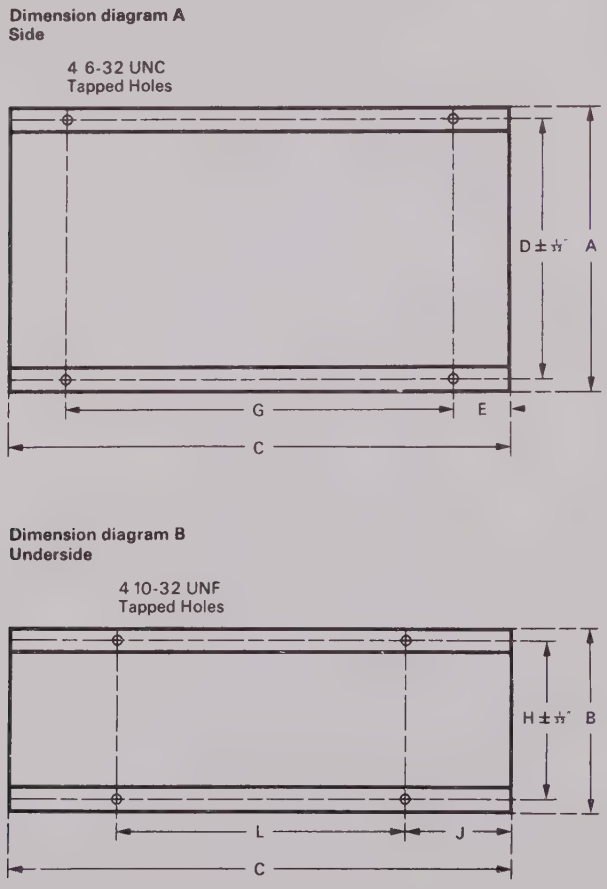


Fig. 1 Fixing Centres

Table 1 Fixing Centre Data

Type	A		B		C		D		E		F	
	in.	cm	in.	cm	in.	cm	in.	cm	in.	cm	in.	cm
PM16	4 3/4	12.07	1	2.54	3 1/8	7.94	2 29/32	7.39	1 1/2	3.81	2 1/8	5.40
PM17	4 3/4	12.07	1	2.54	7 1/4	18.42	2 29/32	7.39	2	5.08	5 1/4	13.3
PM18	4 3/4	12.07	1	2.54	7 1/4	18.42	4 17/64	10.85	2	5.08	5 1/4	13.3
PM19	4 3/4	12.07	1	2.54	7 1/4	18.42	7	17.78	2	5.08	5 1/4	13.3

3.2 AC Supply

Verify that the connections to the primary of supply transformer T1 corresponds to the voltage of the local supply, and that the supply fuse FS1 is correct for the unit in use (see Table 4).

The primary connections of T1 should be paralleled when the local supply is 100 to 125V. Fig. 2 shows the connections for a 110V supply, and Table 2 gives the connections for supplies between 100 and 125V.

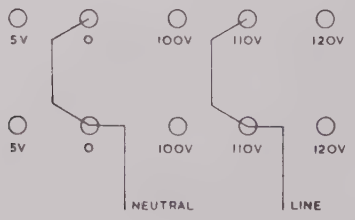


Fig. 2 Transformer Primary Connections for 110V

Table 2 Transformer Primary Connections 100-125V

Supply	Neutral	Line	Neutral Link Between	Line Link Between
100V	0	100	0-0	100-100
105V	5	100	5-5	100-100
110V	0	110	0-0	110-110
115V	5	110	5-5	110-110
120V	0	120	0-0	120-120
125V	5	120	5-5	120-120

When a 200 to 250V supply is available, the primary connections of T1 should be made in series. Fig. 3 shows the series connections to be made for a 240V supply, and Table 3 gives the connections for supplies between 200 and 250V.

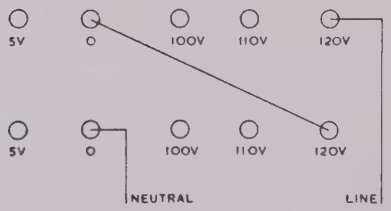


Fig. 3 Transformer Primary Connections for 240V

Table 3 Transformer Primary Connections 200-250V.

Supply	Neutral to Inner Tag	Line to Outer Tag	Diagonal Link Between
200V	0	100	0-100
210V	5	100	5-100
220V	0	110	0-110
230V	5	110	5-110
240V	0	120	0-120
250V	5	120	5-120

Table 4 Fuse Ratings (fuses up to 10A must be H.R.C. type)

HRC type preferred

Power Supply	FS1 Fuse Ratings 200-250V	FS1 Fuse Rating 100-125V	FS2 glass
PM16	1A	2A	2A
PM17	2A	4A	4A
PM18	3A	7A	7A
PM19	5A	10A	12A

3.3 Preliminary Checks

Before the mains supply is connected to the unit, ensure that the correct fuses are fitted as specified in Table 4. Check that the following terminal links on terminal block TB2 (mounted on the front panel) and TB3 (mounted on the left-hand side of the chassis) are in position.

(1) 4 and 5 on TB2 (DC LINK)
(2) 6 (+s) to 7 on TB2)
(3) 9 (-s) to 8 on TB2) DC output
(4) 1 and 2 on TB3 (External programming of current)
(5) 4 and 5 on TB3 (External programming of voltage)

NOTE If these links are not made the unit will not operate satisfactorily.

When the preliminary checks have been completed, connect the mains supply to the following terminals on TB1.

Line to 1
Neutral to 2
Earth to 3

3.4 Internal Programming

(a) Setting the Output Voltage

The level of the output voltage is determined by the SET OUTPUT VOLTS control on the front panel. The control can be set to obtain any level of output voltage in the range 0 to 7V provided that the following conditions are observed.

(1) The load current does not exceed the current limit level determined by the SET OUTPUT CURRENT control on the front panel.
(2) The level of output voltage does not exceed the trip level of the overvoltage protection circuit.

To set the output voltage:

(1) Connect a voltmeter across terminals 6 (+) and 9 (-) on TB2.
(2) Switch on the AC supply.
(3) Adjust the SET OUTPUT VOLTS control to obtain the required level of output voltage as indicated on the voltmeter.

(b) Setting the Output Current.

The current limit level is determined by the SET OUTPUT CURRENT control on the front panel. The control can be set to any value of current within the range 5% to 105% of the maximum rated current of the unit, provided that the load voltage does not exceed the voltage limit level determined by the SET OUTPUT VOLTS control on the front panel. To set the output current:

(1) Connect an ammeter between terminals 7 (+) and 8 (-) on TB2.
(2) Switch on the AC Supply.
(3) Adjust the SET OUTPUT CURRENT control to obtain the required level of output current as indicated on the ammeter.

(c) Overvoltage Setting

(1) Connect a voltmeter from terminal 7 to terminal 8 on TB2.
(2) Set the overvoltage control (RV50) mounted on the Overvoltage Board to the maximum setting - fully clockwise.
(3) Set the SET OUTPUT VOLTS control to obtain a voltmeter indication corresponding to the level at which the overvoltage circuit is to operate.
(4) Slowly turn RV50 counter-clockwise until the overvoltage circuit operates. Operation is evident by a reduction to approximately 1V on the voltmeter.
(5) Set the SET OUTPUT VOLTS control fully counter-clockwise i.e., below 1V. This overrides the operation of the voltage circuit.
(6) Slowly turn the SET OUTPUT VOLTS control clockwise and ensure that a corresponding increase in the indication of the voltmeter occurs.
(7) When the indication of the voltmeter reaches the level of operation of the overvoltage circuit, ensure that the overvoltage circuit operates.

(8) Reset the overvoltage circuit by turning the SET OUTPUT VOLTS control fully counter-clockwise. Then set the control to the required level of output voltage.

N.B. For over-voltage settings above 7 volts which are out of the range of the internal SET OUTPUT VOLTS potentiometer either use must be made of the external voltage, programming facility to achieve these higher voltages or the overvoltage must be applied from some external source of voltage controllable up to 8.5 Volts.

3.5 External Programming

Voltage, current and overvoltage protection levels can be controlled externally. To utilise the facility it is necessary to remove terminal links (which disconnect the internal controls from circuit) and connect external resistors by means of remote lines if necessary. By using resistors whose values correspond to the voltage or current required, voltage control, current control and overvoltage control can be effected remotely.

NOTE

If remote lines are used, their resistance is to be included in the value of the programming resistor and they should be shielded from stray electromagnetic fields to minimise "noise" pick-up.

(a) Voltage Control

For external control of voltage, RV101 is disconnected from circuit and replaced by an external potentiometer or fixed resistor. The level of the output voltage is related to the value of the external resistance by the Ω/V scale factor. This is 100Ω/V for the four power supplies. To connect the unit for external programming of voltage, the procedure is as follows.

(1) Switch off the AC supply.
(2) Disconnect the link across terminals 4 and 5 of TB3.
(3) Connect the external programme resistor to terminal 4 of TB3 and terminal 9 of TB2.
(4) Switch on the AC supply.

(b) Current Control

For external control of current, RV100 is disconnected from circuit and replaced by an external variablemeter or fixed resistor. The level of current is related to the value of the external resistance by the Ω/A scale factor which is given in Section 2 for each one of the four power supplies. To connect the unit for external programming of current, the procedure is as follows.

(1) Switch off the AC supply.
(2) Disconnect the link across terminals 1 and 2 of TB3.
(3) Connect the external programme resistor to terminals 3 and 2 of TB3.
(4) Switch on the AC supply.

(c) Overvoltage Control

For external control of the overvoltage protection circuit, RV50 is disconnected from circuit and replaced by an external potentiometer. A resistance range from 0 to 1kΩ corresponds approximately to an overvoltage protection range of 1.5V to 8V. To connect the unit for external programming of overvoltage protection, the procedure is as follows.

(1) Switch off the AC supply.
(2) Disconnect the link across terminals 4 and 5 of the overvoltage printed circuit board connector.
(3) Connect an external programme potentiometer of 1kΩ resistance to terminals 4 (slider), 6 and 7 of the printed circuit board connector.
(4) Switch on the AC supply.

3.6 Parallel and Series Operation

Up to a maximum of 5 modular power units can be operated in parallel, and should be connected as shown in Fig. 4. For best voltage regulation, the terminal labelled "P" (terminal 6 of TB3) on each unit should be returned to a common point, and four-terminal sensing used - but this is not essential.

NOTE When units are connected in parallel the built in thyristor of the overvoltage circuit in each unit must be made inoperative, because it is not possible to ensure that each thyristor will have an equal share of total current under fault condition. This is done by connecting pins 3 & 6 of the o/v board of each unit.

If overvoltage protection is required, an external thyristor of suitable rating for the total parallel current of all units should be used. Its gate terminal should be connected to pin 3 on the overvoltage board of one unit disconnecting the existing gate connection to MR101. The cathode should be connected to the common negative line and the anode to the common positive line set over voltage as section 3.4(c). All other units should have pins 3 & 6 started as outlined above.

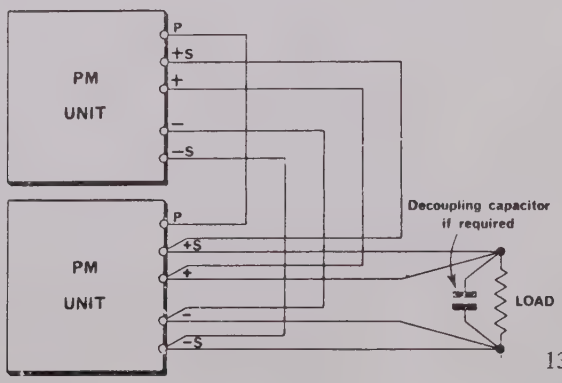


Fig. 4 Parallel Operation

It is also possible to operate modular power units in series under certain conditions as follows.

(1) If necessary each unit is to be set up separately to the required operating conditions as detailed in paragraphs 3.4 and 3.5.
(2) A diode, of the same current and voltage rating as the power module, must be connected across EACH power module output (positive end of diode to positive terminal of power module).
(3) The number of modules connected in series is limited to a maximum of 250V DC.

3.7 Operation with other Power Supply Units

When power modules are used in conjunction with other power supplies of opposite polarity, provision must be made as in 3.6 (2) to protect the power module against reverse voltage conditions. The rating of the diode used must be sufficient to carry the fault current generated.

3.8 Four-terminal Sensing

Where long external output leads are used, four-terminal sensing is provided to enable the load voltage regulation of the power supply to be maintained at the load connections. The two links between the +ve output and the +ve sense, and the -ve output and the -ve sense terminals should be removed and connections made as shown in Fig. 5. These output connections should be run together and a decoupling capacitor, similar to C102 in the power supply, connected at the load terminals if the high frequency output impedance is to be maintained. Parallel connection should be made as shown in Fig. 6.

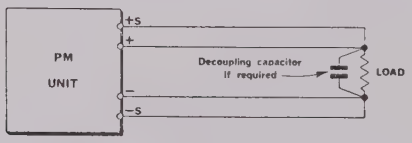


Fig. 5 Four-terminal Sensing

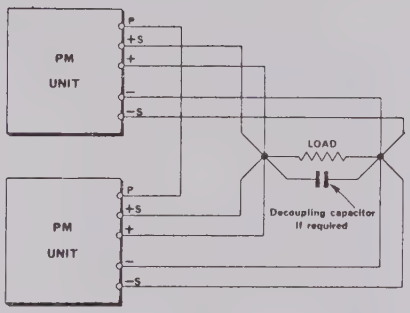


Fig. 6 Four-terminal Sensing (parallel)

The maximum permissible voltage drop in the external leads when using four-terminal sensing is 0.5V total in both leads, i.e., 0.25V in each lead +ve and -ve or 0.5V in one supply lead with an earth return of negligible resistance. The total permissible length of lead for 0.5V drop is listed in Table 5 for various wire sizes and current ratings. Note that this is the total permissible loop length "go and return" and that the power supply can only be situated at half this distance from the load for a two wire +ve and -ve lead system.

Table 5 Permissible Lead Length for 4-terminal Sensing

Wire Size	Lead Length (feet and metres)							
	PM16		PM17		PM18		PM19	
	ft	m	ft	m	ft	m	ft	m
7/0076	19	6						
14/0076	38	12	13	4				
23/0076	60	18	20	6	12	3.5		
40/0076			68	21	21	6.5	10	3
70/0076					37	11	18	5.5
110/0076					58	18	29	9
162/0076							43	13

4.1 General

A simplified functional diagram of the circuitry of the power supplies in the PM16-PM19 range is shown in Fig. 8. The voltage and current modes of operation are controlled by two independent bridge circuits. Any variation of load current or output voltage produces an out-of-balance condition of the associated bridge. The output of the bridge is applied to a comparator amplifier whose output is fed into a mode gate. The output of the mode gate controls the output resistance of a series regulator which (assuming the initial variation was within the preset operating limits of the unit) restores the original mode conditions.

The circuit cannot operate in both modes simultaneously, and only the control signal from the bridge corresponding to the mode of operation passes through the gate. Crossover from one mode to another is automatic, and the point of crossover is determined by the settings of the two front-panel controls SET OUTPUT VOLTS (RV101) and SET OUTPUT CURRENT (RV100)

An auxiliary stabilised power supply is also incorporated. This supplies the bridge circuits and the comparator amplifiers; to simplify the functional diagram, the output connections of the auxiliary supply are not shown. Overvoltage protection is afforded by a sensing circuit connected across the stabilised output terminals. The level at which the circuit operates is controlled by the setting of a potentiometer.

The circuit diagram is shown in Fig. 10. Two sections of the circuit are enclosed in chain dotted outlines to indicate the components mounted on the Control Board and the Overvoltage Board.

4.2 Supply Rectification and Smoothing (Fig. 10)

The AC input voltage within the range 100V to 250V, 45 Hz to 450 Hz is applied, via the front-panel terminal strip TB1, to the primary of T1. Interconnection of the primary terminals for different voltage supplies is given in Section 3.

The transformer has two secondary windings. The output voltage derived from one winding is used for the auxiliary supply. The AC voltage is full-wave rectified by MR1 and MR2 and smoothed by R1, C1 and C2. The output voltage of the other winding is applied to the bridge rectifier MR100 and then smoothed by C101. The resultant "raw" DC is protected by fuse FS2 and then applied via the DC link to the series regulator. If a remote control facility is required, the DC link can be removed and an external switching device connected. If FS2 blows or the link is open circuit, a discharge path for C101 is still available through R100.

4.3 Series Regulator

The series regulator contains transistor VT100 and transistor VT101 arranged in a Darlington-pair configuration. An increasing positive signal applied to the base of VT100 decreases the output resistance of the circuit;

conversely, a decreasing positive signal increases the output resistance. Each transistor in VT101 has a separate resistor in the emitter circuit. The voltage developed by the flow of load current through the series resistors R101 is connected across a common potential divider network of resistors R102, R103 and R104. Resistors R103, R104 form one arm of the current bridge, and the signal voltage developed across them is used for current mode control.

4.4 Bridge Reference Sources

Two Zener diodes, MR4 and MR5, are used as reference sources in the voltage and current bridges, respectively. These diodes are connected in series with the resistor network of R10, R11 and R12 across the auxiliary voltage supply line, and MR4 is also used as the reference for the stabilising circuitry of the auxiliary voltage supply. The flow of current through the two diodes is determined by accurate adjustment of the value of the resistor network. This level of current is maintained by the stabilised auxiliary voltage.

4.5 Stabilisation of the Auxiliary Supply

Stabilisation is effected by the sensing network R5, R6 and R9 and the associated circuitry of transistors VT1 to VT4. A proportion of any change in the auxiliary voltage is fed to the base of VT3 which is in a long-tail pair configuration with VT4. Assume that the voltage across the sensing network tends to rise. An increase in the voltage drop across R6 occurs. This increases the base voltage of VT3 which is compared with the fixed base voltage of VT4 established by MR4. The resultant positive increase of the collector potential of VT4 decreases the conduction of VT2; the emitter voltage of VT2 is fixed by Zener diode MR3. As a result, the decreased conduction of VT2 reduces the base drive of the series regulator transistor VT1. Thus, the resistance of VT1 increases and counteracts the initial tendency of the output voltage to rise; Resistor R4 ensures initial conduction of VT1.

4.6 Voltage Control Bridge

The circuitry which senses any tendency of the output voltage to change is shown in a bridge configuration in Fig. 8. Any unbalance of the bridge is detected by the long-tail pair VT5 and VT6 which operate as the voltage comparator amplifier. The two diodes, MR6 and MR7, connected from the base of VT5 to the base of VT6 protect the two transistors against heavy discharge currents from C102 if the capacitor is in a charged condition when the sense lines are connected.

The base voltage of VT6 is obtained from the positive sense line and follows the level of the stabilised output voltage across the load. The base voltage of VT5 is stabilised at a level determined by the settings of RV101 because the variable resistor in conjunction with the resistor network of R14, R15 and R16 forms a potential divider of the stabilised voltage at MR4 cathode with respect to the negative output terminal of the stabilised supply. It should be noted that the emitter circuit of the long-tail pair is returned to the negative side of the auxiliary supply.

As shown in Fig. 8, the resistor network and RV101 form two arms of the voltage control bridge. When the bridge is balanced, the voltage condition is as follows.

$$V_{MR4} = V_{R1}$$

$$V_{RV101} = V_{OUT}$$

For V_{OUT} to equal V_{RV101} at all settings of RV101, the output voltage must be a direct function of the resistance of RV101. This factor enables external adjustment of the voltage to be made (see External Programming).

4.7 Voltage Setting

Consider that the bridge is balanced, and that it is required to set the output voltage from a low level to a higher level. Assume that initially the level of the stabilised output voltage remains constant. Adjustment of RV101 to obtain a higher output voltage increases the resistance of RV101 and increases the base voltage and collector current of VT5. The resultant decreasing positive level of the collector voltage of VT5 is applied to MR8 which with MR9 forms the mode gate. A decreasing positive signal to MR8 results in a decrease of output resistance of the series regulator (see Mode of Operation). The output voltage thus rises, and the base voltage of VT6 is re-established at the level determined by the setting of RV101, i.e., the bridge is balanced and the differential input to the long-tail pair is zero.

4.8 Dynamic Control of Voltage

With the bridge balanced, the circuit will remain in equilibrium until the output voltage tends to change. Any change in output voltage across the load is fed back, via the positive sense line, to the base of VT6 where it is compared with the base voltage of VT5. The resultant output of VT5 is then applied to the mode gate to change the output resistance of the series regulator to counteract the change.

4.9 Current Control Bridge

The circuitry which senses any tendency of the output current to change is shown in a bridge configuration in Fig. 9. Any variation in output current is indicated by the voltage variation produced across the two parallel resistors R103 and R104. Any unbalance of the bridge is detected by the long-tail pair VT7 and VT8 which operate as the current comparator amplifier. The base voltage of VT8 is fixed by MR5; note that the base of VT8 is returned via the sense line to the cathode of MR5. The base of VT8 is also connected to one end of resistors R103 and R104. The base voltage of VT7 is determined by the setting of RV100 which in conjunction with the resistor network of R20, R21 and R22 forms a potential divider of the voltage at the junction of RV100 and R103 with respect to the negative side of the auxi-

liary voltage. Note that the negative side of the auxiliary voltage is the common return for the emitter and base circuits of the comparator. As shown in Fig. 8, the resistor network and RV100 form two arms of the current control bridge. When the bridge is balanced, the voltage condition is as follows.

$$V_{MR5} = V_{R2}$$

$$V_{RV100} = V_{S}$$

For V_{RV100} to equal V_S at all settings of RV100, the current through R103 and R104 must be a direct function of the resistance of RV100. This factor enables external adjustment of the current to be made (see External Programming).

4.10 Current Setting

Consider that the bridge is balanced and that it is required to set the output current from a high level to a lower level. Assume that initially the level of the current remains constant. Adjustment of RV100 to obtain a lower level of current decreases the resistance of RV100. As a result, the potential across the resistor network of R20, R21 and R22 rises and causes the conduction of VT7 to increase. The resultant increasing positive level of the collector voltage of VT8 is applied to MR9 which with MR8 forms the mode gate. An increasing positive signal to MR9 results in a increase of output resistance of the series regulator (see Mode of Operation). As a result, the current falls and the voltage drop across resistors R103, R104 changes to a value which is equal to the voltage drop across RV100, i.e., the bridge is balanced and the differential input to the long-tail pair is zero.

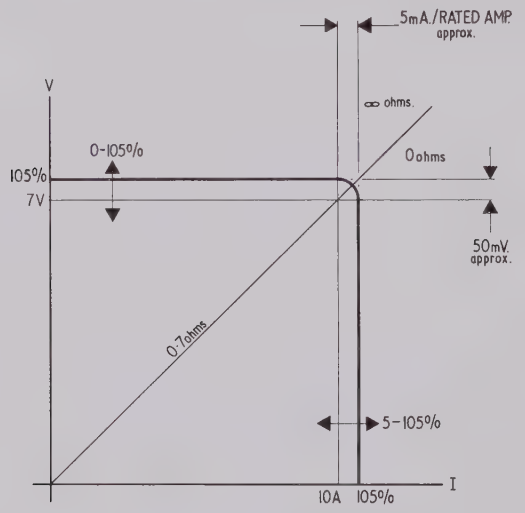
4.11 Dynamic Control of Current

With the bridge balanced, the circuit will remain in equilibrium until the output current tends to change. Any change of load current changes the voltage drop across resistors R103, R104 with respect to the base of VT8. A proportion of this voltage change is applied, via RV100 and the resistor network, to the base of VT7. The resultant change in the positive level of the collector voltage of VT8 is then applied to the mode gate to change the output resistance of the series regulator to counteract the change.

4.12 Mode of Operation

The mode of operation of the power supply is determined by the load conditions and the settings of RV100 and RV101. Automatic crossover from one mode to the other is depicted in Fig. 7 and occurs at the value of load resistor designated R_C. The value (in ohms) of the load resistor R_C is obtained by dividing the voltage (volts) set by RV101 and the current (amps) set by

RV100. When the power supply is connected to any load R_{CV} whose resistance is more than R_C, the mode of operation is constant voltage. When the resistance of the load decreases to any value R_{CC} below R_C, the mode of operation is constant current.



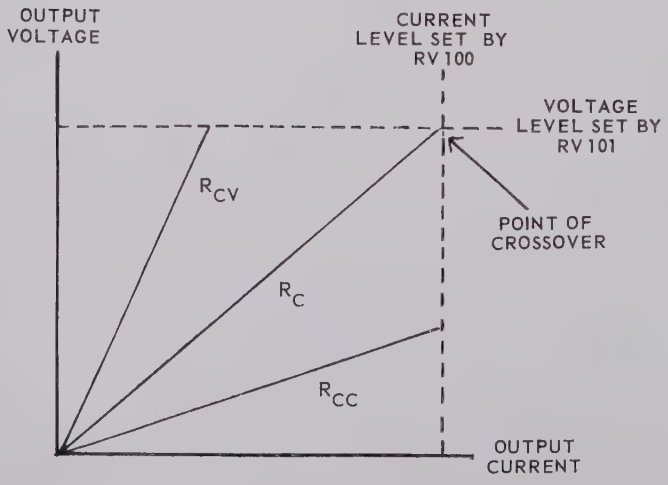


Fig. 7 The Crossover Load

4.13 Mode Gate

During either mode of operation, both comparator amplifiers produce output voltages which are applied to two diodes in the mode gate. Diode MR8 is controlled by the output of the voltage comparator (collector of VT5), and diode MR9 is controlled by the output of the current comparator (collector of VT8). The diode which conducts is the one receiving the higher output voltage. The output from the conducting diode is amplified by VT9 and then applied, via the emitter-follower VT10, to the series regulator. Except for a brief transitional period at crossover, both diodes do not conduct simultaneously; thus, it is always the higher output of the two comparators which controls the resistance of the series regulator. Note that VT9 introduces polarity inversion, and a high positive output from the mode gate produces high resistance of the series regulator.

4.14 Crossover in the Mode Gate

The crossover action is best understood by considering the operation of the control circuits as the resistance of the load is decreased from a high value of R_{CV} to a low value below R_C. At first, with a very low load current flowing, the collector voltage of VT8 is very low because the voltage developed across R103, R104 is low, and the resultant low base voltage of VT7 allows VT8 to conduct heavily. At the same time, the collector voltage of VT5 is high because with low load current the stabilised output voltage tends to rise, but is held at its predetermined level by heavy conduction of VT6 which results in a high positive potential at the collector of VT5. Thus, of the two signals applied to the mode gate, the signal from VT5 will take control and effect the high value of output resistance required of the series regulator.

As the resistance of the load is decreased, VT7 senses the increased voltage drop across R103, R104 and increases conduction. This decreases the conduction of VT8 and its collector potential rises. Simultaneously, the collector voltage of VT5 decreases in order to reduce the output resistance of the series regulator so that the higher load current may flow.

This action of the collector voltage of VT8 rising and that of VT5 falling as the resistance of the load decreases continues until at the crossover point the signal from VT8 takes control and a rapid transition from voltage mode to current mode occurs. The output supply voltage of the unit then falls to the level required to sustain the preset current level. This rapid transition from voltage mode to current mode provides overcurrent protection.

4.15 Overvoltage Protection

The overvoltage protection circuit uses a long-tail pair comparator circuit containing transistors VT50 and VT51. The input to the base of VT51 is derived from R55 which with R54 forms a potential divider across the stabilised output supply. VT51 base voltage is compared with the base voltage of VT50 derived from the potentiometer RV50 connected across a Zener diode

reference source MR50. The level at which overvoltage protection is required is effected by the setting of RV50; because this level is obviously above the stabilised output voltage, the normal quiescent condition of the long-tail pair is such that VT50 is conducting much more than VT51. In practice, the overvoltage limit is set approximately 10% above the level of the stabilised voltage. If the stabilised output voltage rises above the level set by RV101, transistor VT51 conducts and drives VT52 into heavy conduction. The base voltage of VT52 is fixed by the Zener diode MR51; consequently, VT52 provides a constant current to the gate electrode of SCR MR101 which fires and produces a short circuit across the terminals of the stabilised output supply.

4.16 External Programming

As explained during the description of the voltage and current control bridges, the balance conditions of the bridges are such that the following conditions exist.

(1) The voltage across the resistance of RV101 (SET OUTPUT VOLTS) is equal to the output voltage. A change of resistance of RV101 produces a directly proportional change of output voltage.
(2) The voltage across the resistance of RV100 (SET OUTPUT CURRENT) is equal to the voltage across resistors R103, R104 which, in turn, is directly proportional to output current. A change of resistance of RV100 produces a directly proportional change of output current.

Thus, resistance-output voltage and resistance-output current relationships exist, and these are expressed as Ω/V and Ω/A scale factors, respectively. By disconnecting the variable resistors from circuit and in their place connecting - by remote lines if necessary - fixed or variable resistors, the output voltage or current level can be set by altering the value of resistance. The advantage of this circuit facility is that without any monitoring or metering aid, the voltage and current level can be set simply by the value of resistance in circuit. The method of connecting the unit for external programming of output voltage, output current and overvoltage protection is detailed in Section 3.

5.1 Access to Components

All components, except those mounted on the printed circuit boards, are accessible after removing the front panel (held by fixing screws) and detaching the heat sink assemblies from the side bars. Access to the components on the printed circuit board during operating conditions may be obtained by removing the board and connecting it to the socket in the unit via an extension board (Advance Part No. 19014).

NOTE The printed circuit boards must not be removed from the modules without first switching off the AC supply.

5.2 Replacement Servicing of Printed Circuit Boards

The Control Boards used in any of the units in the PM16-PM19 range are interchangeable. The Overvoltage Boards in the PM16, PM17 and PM18 units are also interchangeable. In the largest unit, the PM19, the arrangement of some components is different and prevents the interchanging of the Overvoltage Board with one from the other three units.

The extension board is available as a servicing aid. This board can be used as an extended connector for any printed circuit board in the entire range PM1-PM19 of modular Stabilised Power Supplies.

All boards are available as spare parts, and the following Advance Part No. should be quoted when ordering.

(1) Control Board (PM16-PM19)	Advance Part No. 22859
(2) Overvoltage Board (PM16, PM17, PM18)	Advance Part No. 23321
(3) Overvoltage Board (PM19)	Advance Part No. 23352
(4) Extension Board	Advance Part No. 19014

5.3 Fault Finding

Determine the state of the output voltage on load and proceed as outlined in Table 6.

Table 6 Fault Finding Chart

Output Voltage	Fault	Action
No Output	Fuse blown	Change fuse
	MR100 open circuit	Change MR100
	DC link open circuit	Replace link or check external switching device
	VT101 open circuit	Change VT101
	Printed circuit board out of socket or faulty	Replace with new assembly.
Low output	MR100 partially open circuit	Change MR100
	DC link high resistance	Tighten screws or check external switching device.
	+ve or -ve sensing link open circuit	Replace link
	Printed circuit board faulty	Replace with new assembly.
High unstabilised output. High ripple	VT100 short circuit VT101 short circuit Printed circuit board faulty	Change VT100 Change VT101 Replace with new assembly.

For component information, look under the basic title in the range PM16-PM19 and under the appropriate title of the printed circuit board.

PM16 MODULES

Ref.	Value	Description	Part No.
Resistors (5% Electrosil TR5 unless specified)			
R100	680		19143
R101	1	5% C.G.S. VPF-10	23066
R102	2 X 10		19339
R103	56		19135
R104	Adjusted on test		
R105	Adjusted on test		
R106	Adjusted on test		
R107	270		19141
R108	3.9k		18701
RV100	1.2k	Colvern CLR 1106/9S	23062
RV101	800	Colvern CLR 1106/9S Cu/Ni	23333
Capacitors			
C100	0.1µF	10% 160V Mullard C296AA/A	804
C101	2700µF	25V Sprague 36D272GO25AA2A	22704
C102	500µF	40V Mullard C431 BM/G500	3102
Diodes			
MR100		Bridge rectifier Pirelli W005	19724
MR101		Thyristor BTY79/15OR	18693
Transistors			
VT100		RCA 40250	4224
VT101		RCA 2N3055	3813
Miscellaneous			
T1		Transformer MT519	MT519
FS1		Fuse:-	
	1A	200-250V Belling-Lee L754	23328
	2A	100-125V Belling-Lee	1255
FS2	2A	Belling-Lee L562	21189
			25088

PM17 MODULES

Ref.	Value	Description	Part No.
Resistors (5% Electrosil TR5 unless specified)			
R100	330	5% Electrosil TR6	23364
R101	2 X 0.68	5% C.G.S. VPF-10	23067

Ref.	Value	Description	Part No.
R102	2 X 10		19339
R103	39		19133
R104	Adjusted on test		
R105	Adjusted on test		
R106	Adjusted on test		
R107	270		19141
R108	15k		18708
RV100	1.2k	Colvern CLR 1106/9S	23062
RV101	800	Colvern CLR 1106/9S Cu/Ni	23333
Capacitors			
C100	0.1µF	10% 160V Mullard C296AA/A	804
C101	9600µF	25V Sprague 36D962G025AD2A	22705
C102	1250µF	25V Mullard C431 F1250	19215
C103	0.1µF	10% 160V Mullard C296AA/A	804
Diodes			
MR100		Bridge rectifier Texas 1B40K20	17763
MR101		Thyristor BTY87/100R	23074
Transistors			
VT100		RCA 40250	4224
VT101		2 X RCA 2N3055	3813
Miscellaneous			
T1		Transformer MT520	MT520
FS1		Fuse:-	
	2A	200-250V Belling-Lee L754	1255
	4A	100-125V Belling-Lee	5120
FS2	4A	Belling-Lee L562	5120

PM18 MODULES

Ref.	Value	Description	Part No.
Resistors (5% Electrosil TR5 unless specified)			
R100	270	5% RRC LG75	19641
R101	3 X 0.56	5% C.G.S. VPF-10	23068
R102	3 X 15		19129
R103	150		19139
R104	Adjusted on test		
R105	Adjusted on test		
R106	Adjusted on test		
R107	270		

Ref.	Value	Description	Part No.
R108	Not required		
RV100	1.2k	Colvern CLR 1106/9S	23062
RV101	800	Colvern CLR 1106/9S Cu/Ni	23333
Capacitors			
C100	0.1µF	10% 160V Mullard C296AA/A	804
C101	18000µF	25V Sprague 36D183G025BC2A	22707
C102	2000µF	25V Mullard C431 BR/F2000	4847
C103	0.1µF	10% 160V Mullard C296AA/A	804
Diodes			
MR100		Bridge rectifier Semtech SCBA2	22721
MR101		Thyristor BTY87/100R	23074
Transistors			
VT100		RCA 40250	4224
VT101		3 X RCA 2N3055	3813
Miscellaneous			
T1		Transformer MT521	MT521
FS1		Fuse:-	
	3A	200-250V Belling-Lee HRC size 0	12699
	7A	100-125V Belling-Lee	13040
FS2	7A	Belling-Lee L1055	21183

PM19 MODULES

Ref.	Value	Description	Part No.
Resistors (5% Electrosil TR5 unless specified)			
R100	270	5% RWV4-J	19641
R101	5 X 0.47	5% C.G.S. VPF-10	23069
R108	Not required		
RV100	1.2k	Colvern CLR 1106/9S	23062
RV101	800	Colvern CLR 1106/9S Cu/Ni	23333
Capacitors			
C100	0.1µF	10% 160V Mullard C296AA/A	804
C101	2700µF	25V Sprague 36D272G025AA2A	22704
C102	500µF	40V Mullard C431 BM/G500	3102
C103	0.1µF	10% 160V Mullard C296AA/A	804
Diodes			
MR100		Bridge Rectifier Semtech SCBA2	22721
MR101		Thyristor BTY91/100R	19537
Transistors			
VT100		RCA 40250	4224
VT101		5 X RCA 2N3055	3813
Miscellaneous			
T1		Transformer MT522	MT522
FS1		Fuse:-	
	5A	200-250V Belling-Lee L693	638
	10A	100-125V Belling-Lee	4227
FS2	12A	Belling-Lee L1055	20834

PRINTED CIRCUIT BOARD
(Assy. No. 22859)
FOR PM16-PM19 MODULES

Ref.	Value	Description	Part No.
Resistors (5% Electrosil TR5 unless specified)			
R1	82		19137
R2	5.6k		18717
R3	1k		19338
R4	560		18774
R5	2k		18712
R6	1.1k		19575
R7	5.6k		18717
R8	12k		19145
R9	470		18713
R10	200	1% Electrosil TR5	20086
R11	510		19571
R12	Adjusted on test		
R13	33k		18705
R14	560	5% C.G.S. CR1.5	23232
R15	100	5% C.G.S. CR1.5	22966
R16	Adjusted on test		
R17	4.7k		18706
R18	33k		18705
R19	4.7k		18706
R20	5.6k		18717
R21	1.2k		18700
R22	Adjusted on test		
R23	15k		18708
R24	6.8k		18714
R25-R30	Not used		
R31	680		19143
R32	47		19134
R33	47		19134
Capacitors			
C1	25µF	40V C428AR/G25 Mullard	20082
C2	50µF	40V C428AR/G50 Mullard	23335
C3	.01µF	250V DC Mullard C280 AE/P10K	23336
C4	12.5µF	25V Mullard C428/F12.5	22724
C5	.01µF	250V DC Mullard C280 AE/P10K	23336
Diodes			
MR1		A.E.I. MS4H	20422
MR2		A.E.I. MS4H	20422
MR3		S.T.C. ZF5.6 Zener	4109
MR4		Int. Rect. IN821 Zener	23231

PRINTED CIRCUIT BOARD
(Assy. No. 22859)
FOR PM16-PM19 MODULES

Ref.	Value		Description	Part No.
MR5		S.T.C. ZF5.1	Zener	20218
MR6		A.E.I. MS1H		18806
MR7		A.E.I. MS1H		18806
MR8		A.E.I. MS1H		18806
MR9		A.E.I. MS1H		18806
Transistors				
VT1		RCA 2N3053		4039
VT2		Mullard BCY33		2914
VT3		Texas 2S745A		20831
VT4		Texas 2S745A		20831
VT5		Texas 2S745A		20831
VT6		Texas 2S745A		20831
VT7		Texas 2S745A		20831
VT8		Texas 2S745A		20831
VT9		Texas 2S745A		20831
VT10		Texas 2S745A		20831

PRINTED CIRCUIT BOARD
(Assy. No. 23321)
FOR PM16, PM17, PM18 MODULES

Ref.	Value	Description	Part No.
Resistors (5% Electrosil TR5 unless specified)			
R50	330		19142
R51	1k		19338
R52	1.5k		18709
R53	33		19132
R54	820		18704
R55	1.5k		18709
R56	1k		19338
RV50	1k	Plessey M.P.D.	1054
Diodes			
MR50		S.T.C. ZF5.6 Zener	4109
MR51		Hughes HS7027 Zener	21002
Transistors			
VT50		Texas 2S745A	20831
VT51		Texas 2S745A	20831
VT52		Mullard BFX88	23337

PRINTED CIRCUIT BOARD
(Assy. No. 23352)
FOR PM19 MODULES

Ref.	Value	Description	Part No.
Resistors (5% Electrosil TR5 unless specified)			
R50	330		19142
R51	1k		19338
R52	1.5k		18709
R53	33		19132
R54	820		18704
R55	1.5k		18709
R56	1k		19338
R102	5 X 27		19131
R103	150		19139
R104	Adjusted on test		
R105	Adjusted on test		
R106	Adjusted on test		
R107	270		19141
RV50	1k	Plessey M.P.D.	1054
Capacitors			
C103	0.1µF	10% 160V Mullard C296AA/A	804
Diodes			
MR50		S.T.C. ZF5.6 Zener	4109
MR51		Hughes HS7027 Zener	21002
Transistors			
VT50		Texas 2S745A	20831
VT51		Texas 2S745A	20831
VT52		Texas BFX88	23337

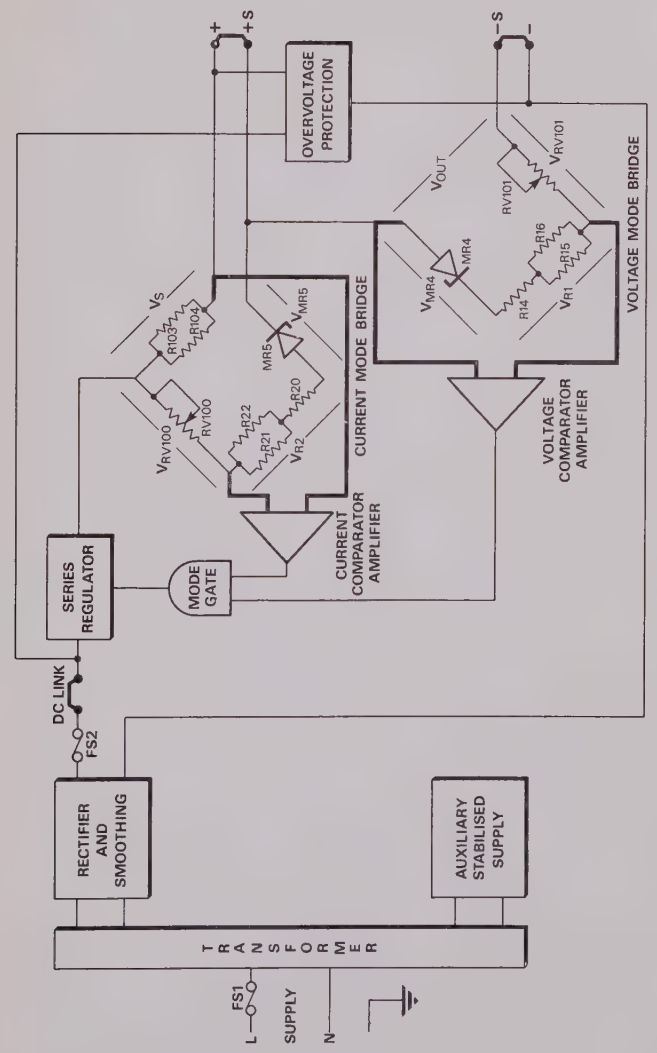


Fig. 8 Functional Diagram

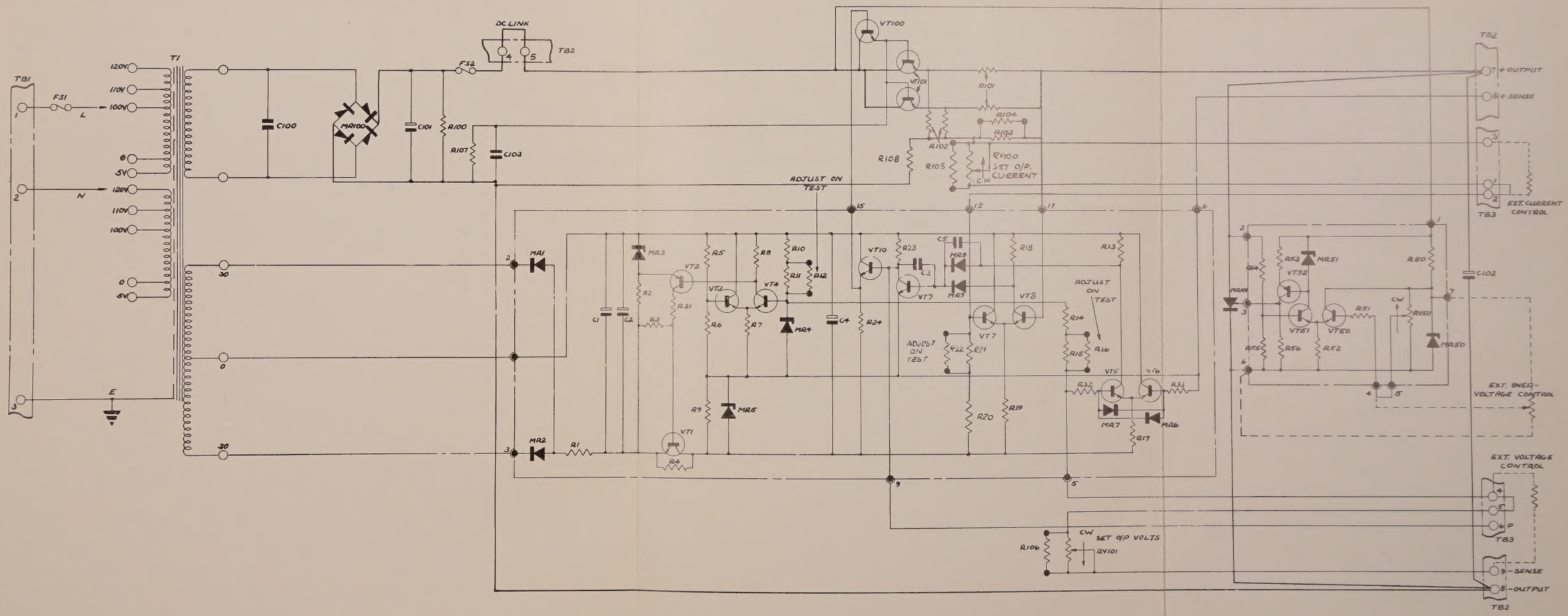


Fig. 9 Circuit Diagram

GUARANTEE AND SERVICE FACILITIES SECTION 7

This instrument is guaranteed for a period of one year from its delivery to the purchaser, covering the replacement of defective parts other than valves, semiconductors and fuses. Valves and semiconductors are subject to the manufacturers' guarantee.

We maintain comprehensive after sales facilities and the instrument can, if necessary, be returned to our factory for servicing. The Type and Serial Number of the instrument should always be quoted, together with full details of any fault and the service required. The Service Department can also provide maintenance and repair information by telephone or letter.

Equipment returned to us for servicing must be adequately packed, preferably in the special box supplied, and shipped with transportation charges prepaid. We can accept no responsibility for instruments arriving damaged. Should the cause of failure during the guarantee period be due to misuse or abuse of the instrument, or if the guarantee has expired, the repair will be put in hand without delay and charged unless other instructions are received.

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